LITHIUM-TITANATE MATERIAL FOR LITHIUM-ION BATTERIES

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Abstract: The lithium-titanate material, with spinel crystal structure is the second commercially used negative electrode material in lithium-ion batteries. The material possess interesting electrochemical properties like long-term durability and stability. On the other hand, the material has lower energy density and is artificially synthesized that makes it less accessible. This article describes the lithium-titanite material as negative electrode in lithium-ion battery.

Keywords: lithium, battery, energy storage, environment

1 INTRODUCTION

Lithium-ion batteries are, without doubt, one of the most promising sort of electrochemical energy sources. Negative electrode materials for lithium-ion batteries are developing towards the aim of high power density, long cycle life, and environmental benignity. As a promising anode material for high power density batteries for large scale applications in both electric vehicle and large stationary power supplies seems to be Lithium-titanate spinel $Li_4Ti_5O_{12}$ (LTO). The LTO anode has become more attractive for alternative anodes for its stability, cyclability and rate performance. The theoretical capacity (175 $mA.h.g^{-1}$), stable voltage plateau around 1.5 V vs. Li/Li^+. From fire safety point of view as a most problematic part appears aprotic electrolyte. The aprotic electrolyte in lithium-ion batteries, commonly made by mixture of different aprotic solvents, e.g. a mixture contains 50 wt% of Dimethyl carbonate (DMC) and 50 wt% of Ethylene carbonate (EC) provides poor thermal stability. Flash point measurements show that around EC/DMC mixture beginning evaporate flammable hassle around 50 °C and around 60 °C released gases might be ignited by flame. As an appropriate substitute for EC/DMC mixture, that is widely spread in lithium-ion systems, can be considered sulfolane. The sulfolane (SL) is organosulfur compound with high thermal resistance, around 165 °C. It can be used the same way as EC/DMC mixture with lithium salt, e.g. $LiPF_6$. In that short text, we would like to present our measurements which explore thermal stability and compatibility LTO-sulfolane system in consideration to standard system made by graphite and EC/DMC solvents mixture [1 – 4].

2 EXPERIMENTS

The experiments, characterization under thermal stressing, aimed to capacity and proper function of LTO-Sulfolane system. Tested system has been exposed to individual temperatures from 25 °C (room temperature), 40 °C, 60 °C to 80 °C. Obtained results are shown in Figure 1, 4 – 7 below. Figure 1, LTO and Figure 2 shows reactions sulfolane with natural graphite, where sulfolane molecules cause graphite exfoliation reactions. Figure 2 and Figure 3 present discharge capacities during charge-discharge cycling of exfoliated graphite.

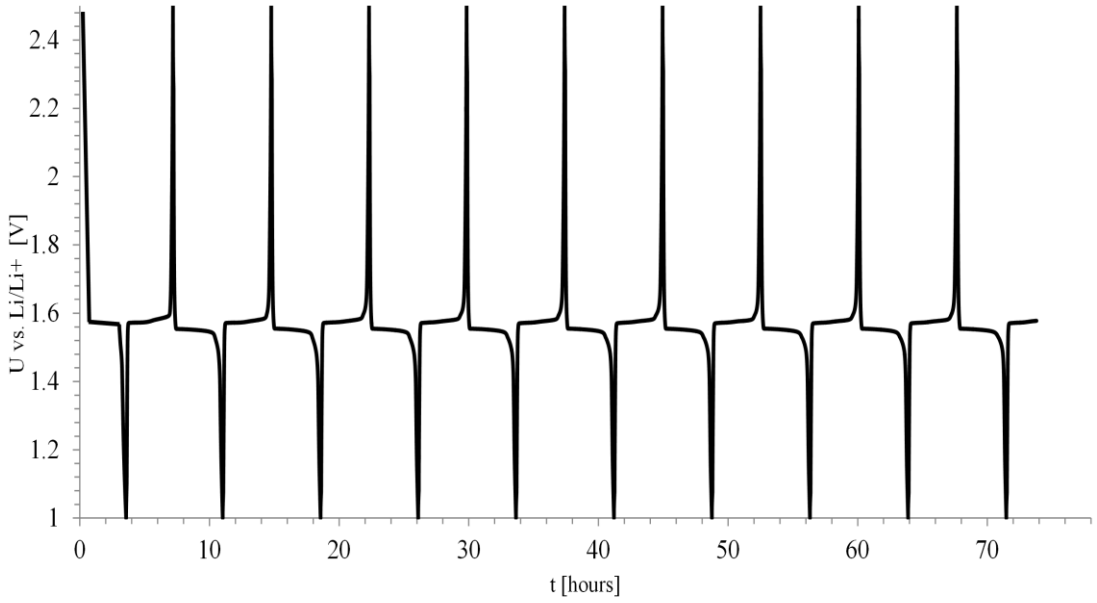

Figure 1: LTO and sulfolane, potential curves at room temperature.

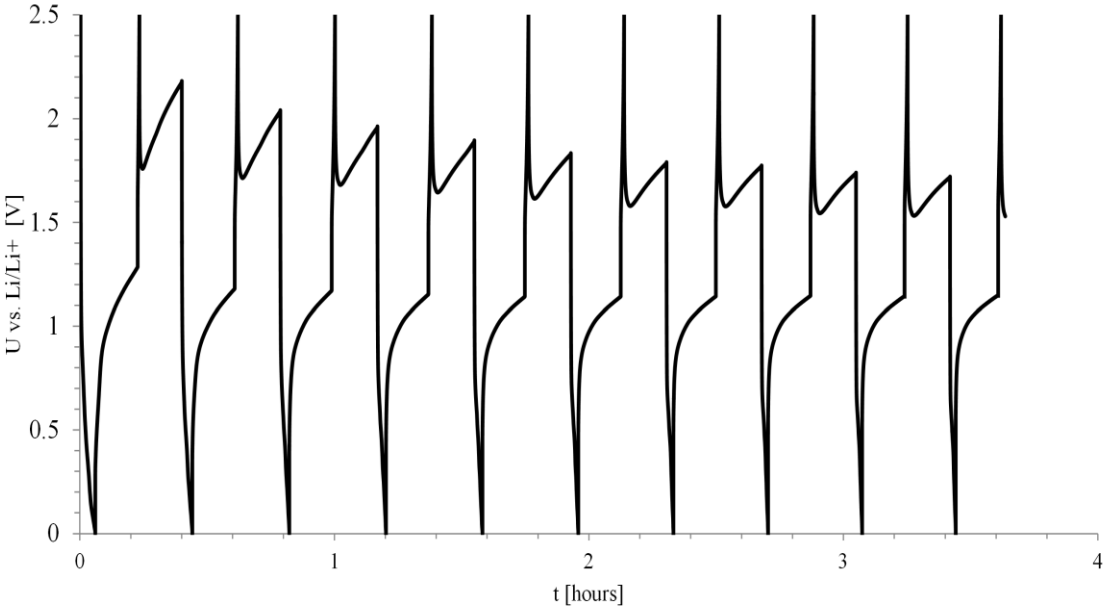

Figure 2: Natural graphite and sulfolane, potential curves at room temperature.

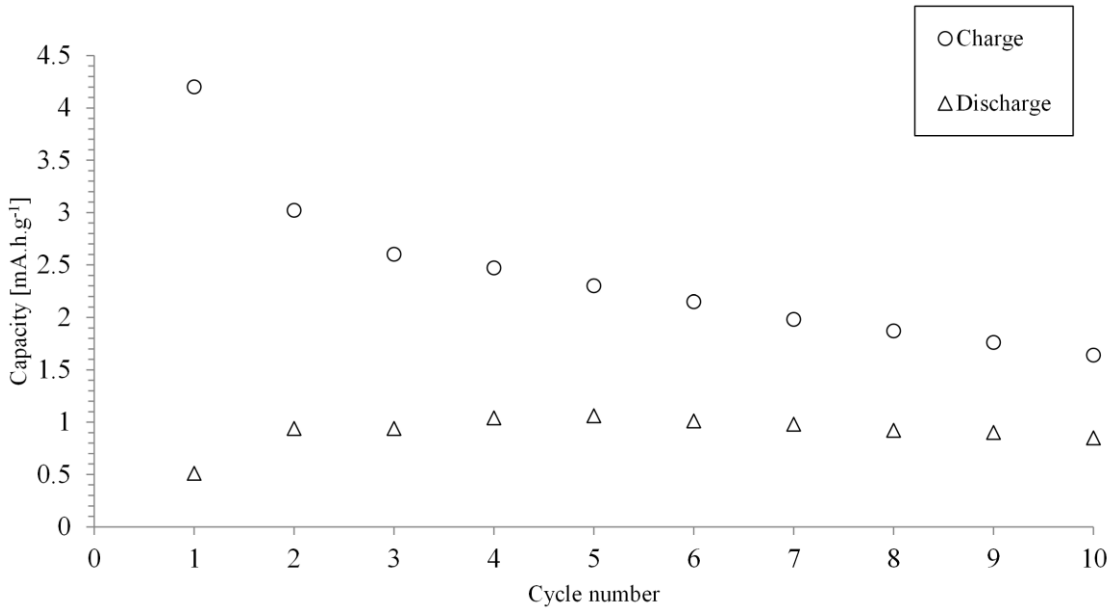

Figure 3: Natural graphite and sulfolane, electrode capacity development through charge-discharge cycles.

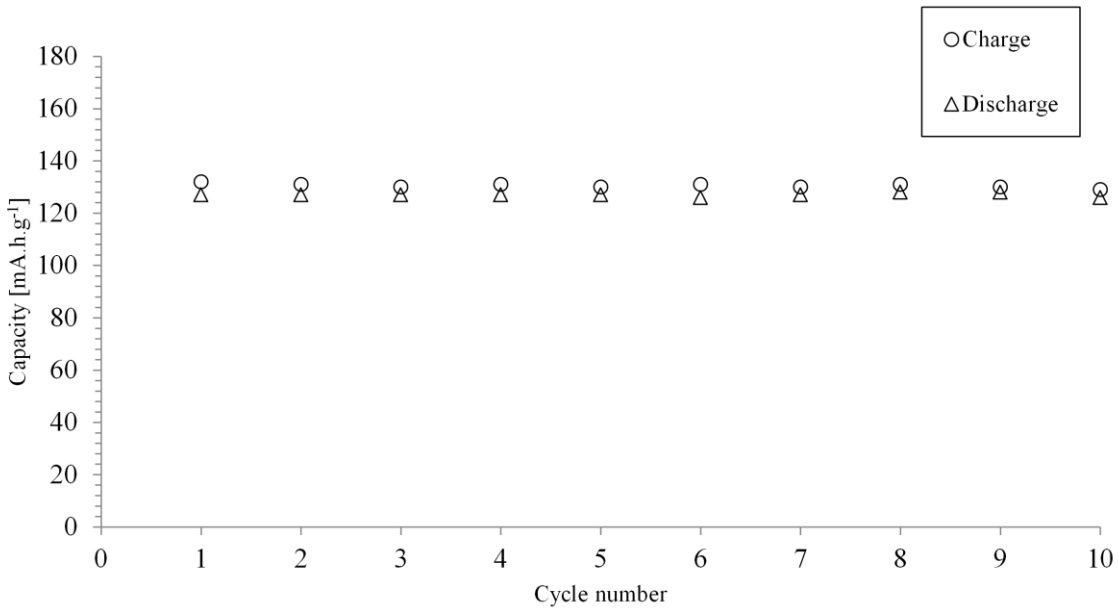

Figure 4: LTO and sulfolane at room temperature.

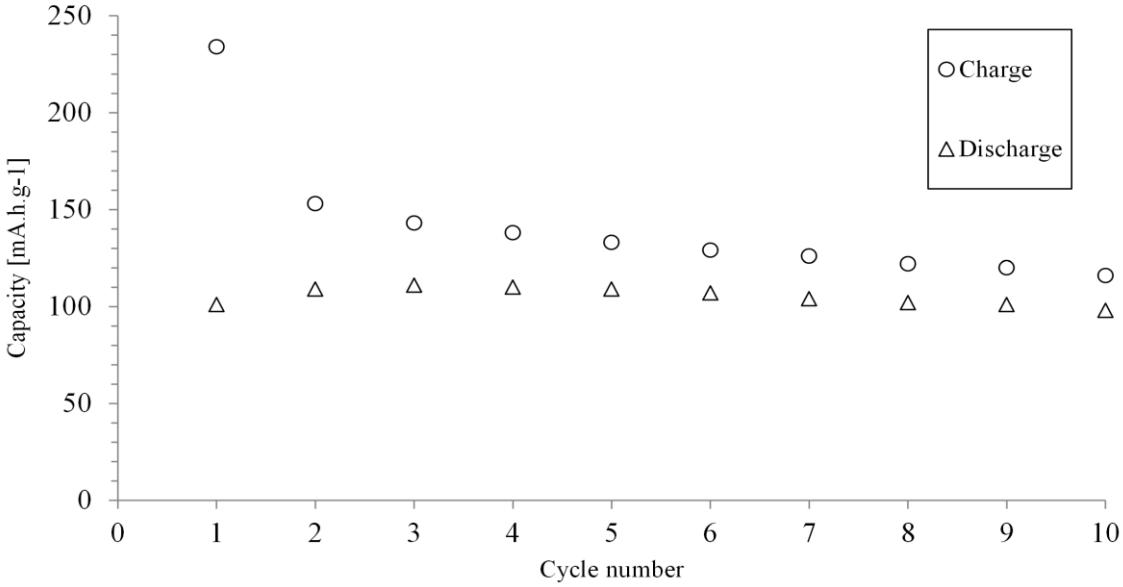

Figure 5: Characteristics measured at 40 °C.

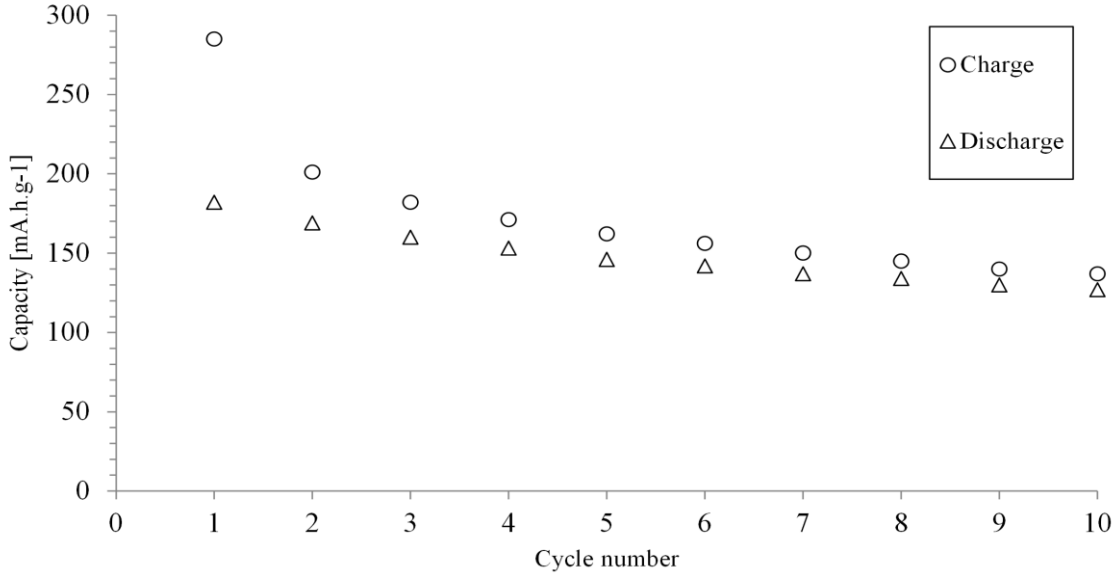

Figure 6: Characteristics measured at 60 °C.

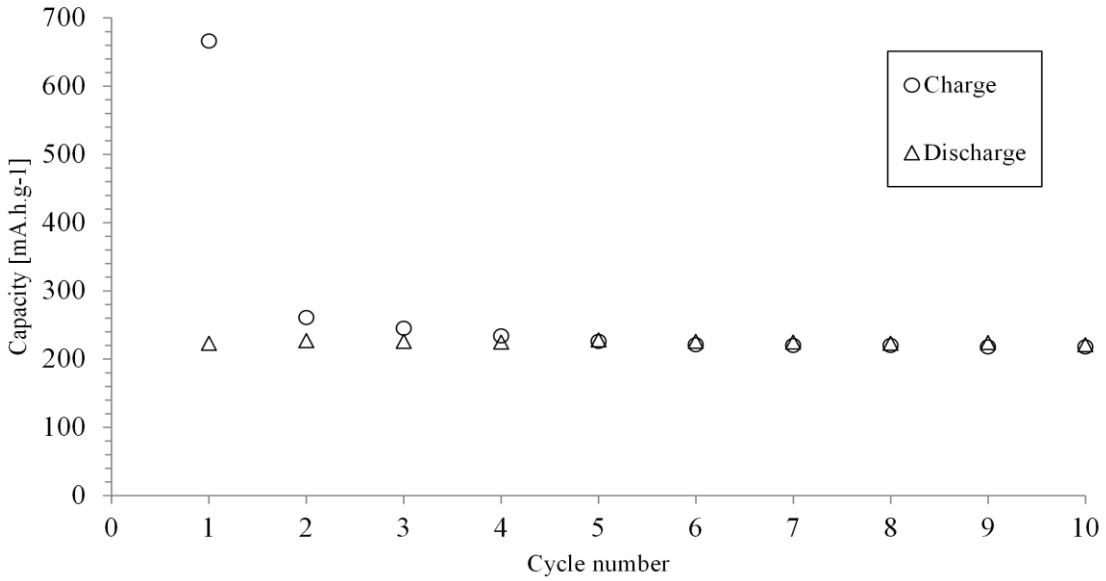

Figure 7: Characteristics measured at 80 °C.

3 CONCLUSION

As can be seen LTO material have got stable capacity through cycles with small irreversible capacity at first cycle, around 4 %. In case of 40 °C there is remarkable change in irreversible capacity development in first cycle, the irreversible capacity grew up to 57 %. This big growth of capacity losses (approx. about 53 %) may be caused by origin of much more thicker SEI layer than in the previous case. The capacity development through cycling show increased irreversible capacity in each cycle (around 15 % related to each individual cycle). For 60 °C is the situation similar, there is a small decrease in irreversible capacity, approx. 36 % along with drop of irreversible capacity in other cycles (around 8 %). For highest temperature, used in our experiments, the first cycle irreversible capacity 66 % has been measured along with very small irreversible capacity in other cycles (approx. 1 %), this behaviour may be caused by SEI layer that is very thick and have small reversible capacity itself. It explains as well why they reached capacities are higher than theoretical capacity of LTO material. This phenomenon is caused by growing of thick layer. However the system with LTO and sulfolane is able to work under high temperature conditions with stable reversible capacity. Other experiments are necessary to understand SEI growing mechanism and decrease irreversible losses.

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